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TO: Professor Clark Lundell, Head, Department of Industrial Design

FROM: Randall Bartlett, Visiting Assistant Professor

SUBJECT: Final Report, NASA Contract NAS 8-39131, Delivery Order No. 28;
"Materials Processing and Development Enclosure."

Introduction

This report, which you requested on July 19, 1994, is a summary of the design sequence, procedures, and results of the student projects this past spring quarter. The report reviews the design process used, selecting of the design teams, critical presentation dates and evaluates the design solutions. Five design teams, consisting of two students per team, designed and presented five full-size glovebox mockups to NASA.

In addition to the glovebox design results, this report list my input with each team. Besides being the professor, I also played the role of a design manager, which allowed me to assist in some decisions that the teams needed. The experience from this project will prove to be an asset to the students, the design staff at NASA, the Department of Industrial Design at Auburn University and myself.

Sources

The primary source of information in this report is based on each teams final design portfolio, which was submitted to me and NASA at the final presentation. This portfolio is a comprehensive design report that includes a history of the glovebox, a patent search, a glovebox component list, concept sketches, anthropometric studies, engineering drawings, and photographs of the final concept. Other information is from my notes I used for grading and from those i took during the concept and final presentation.

Limitations

Interviewing astronauts that use gloveboxes and a better understanding of how zero gravity effects their body movements is needed to accurately evaluate the glovebox designs. This limitation, shared by the students and many NASA designers is one that can only be lessened when a true zero gravity environment is created on earth.

(NASA-CR-196515) MATERIALS
PROCESSING AND DEVELOPMENT
ENCLOSURE Final Report (Auburn
Univ.) 6 p

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Conclusions

1. The glovebox models and the design reports of each team should be evaluated by the design staff at NASA. I suggest that a evaluation checklist be developed, which list performance criteria and parameters. Also, the checklist should include a statistical formula for subjective scoring.
2. Have astronauts that use gloveboxes participate in the evaluation.
3. The pivoting design concept for the contained work volume proposed by Team 3 accommodates the different percentile of users better than the other concepts.
4. Team 1 produced an interesting idea for external mounting of cameras and microscopes. This idea should be considered for a patent. Also, their tool caddie idea solved the problem better than the other designs.

Discussion

This part of the report discusses the events related to the design process used in the development of the glovebox designs. It also includes procedures the student teams used for research, methods developed in determining a design direction to pursue, and information from meetings and presentations.

Initial Visits to NASA

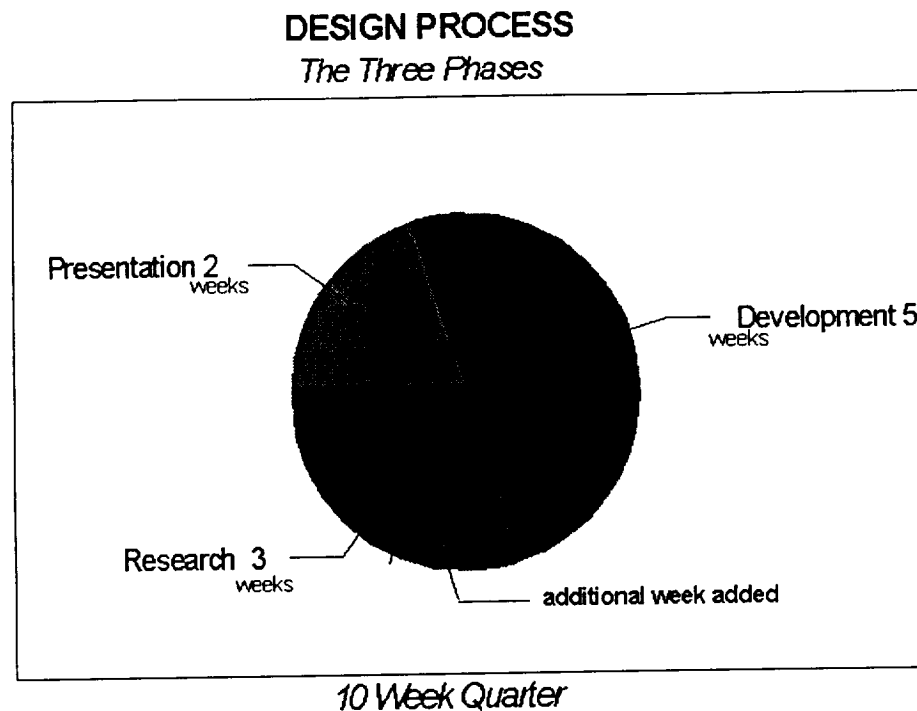
A week before spring quarter classes began, Steven Hall, from the Crew Systems Engineering Branch, met with you and me on March 14, 1994, to discuss the goals of the project. Our goal had two purposes, one that NASA would receive adequate design concepts of a glovebox and that the students have a good educational experience. We agreed that ten design teams of two students each would provide NASA with enough glovebox concepts to use in their further development plans. These concepts, presented in the form of drawings and models, would remain with NASA after the final presentation. The concept and final presentation dates were set as well as a date for the students to visit NASA.

During the first week of the quarter, on April 1, 1994, the student teams went to NASA and met with Steven Hall and the project manager, Terry Jones. At this meeting, Terry Jones presented the scope of the project, including a glovebox component list, which became the primary source of elements required in a glove box. Also, during this visit the students looked at existing gloveboxes and toured the Marshall Space Flight Center.

Glovebox Research and Development Phase

Developing time plans and establishing design goals became the main priority of the teams. All of the teams agreed on one main goal and that was to provide NASA with glovebox designs equal to what they may expect from a professional design consulting office. Even though they are students, they felt confident in delivering quality glovebox designs.

I divided the 10 week quarter into three phases consisting of research, development and presentation. We refer to these phases as the design process. Although the pie graph, shown below, indicates phase segments there is overlapping and feedback from one phase to the other.



The students rely heavily on their research throughout the entire design process. Considering the scope of the project, I added an extra week to the typical two week period for research. This proved to be a benefit in allowing the students to spend more time in researching the effects of zero gravity on the user and to investigate existing gloveboxes used on the Auburn University campus.

Using the body measurements, of a 5 percentile adult Japanese female woman and a 95 percentile United States male, the students established mounting ranges for glove ports, control panels, video monitor, cameras, lighting devices, tool caddie, and the size of the contained work volume. This data gave the teams a foundation for developing their design ideas. While evaluating their glovebox ideas each team selected three concepts to develop and present to NASA during the concept presentation.

Concept Presentation to NASA Officials

On April 29, 1994. Steven Hall, Terry Jones, and other NASA officials including two outside contractors, came to the Department of Industrial Design, Auburn University, to review the progress of the glovebox project.

The teams presented three full size cardboard mockups of their concepts. These mockups were housed in racks that resemble those used in the space station. The contained work volume, glove ports, controls, and other glovebox components were indicated on the mockups.

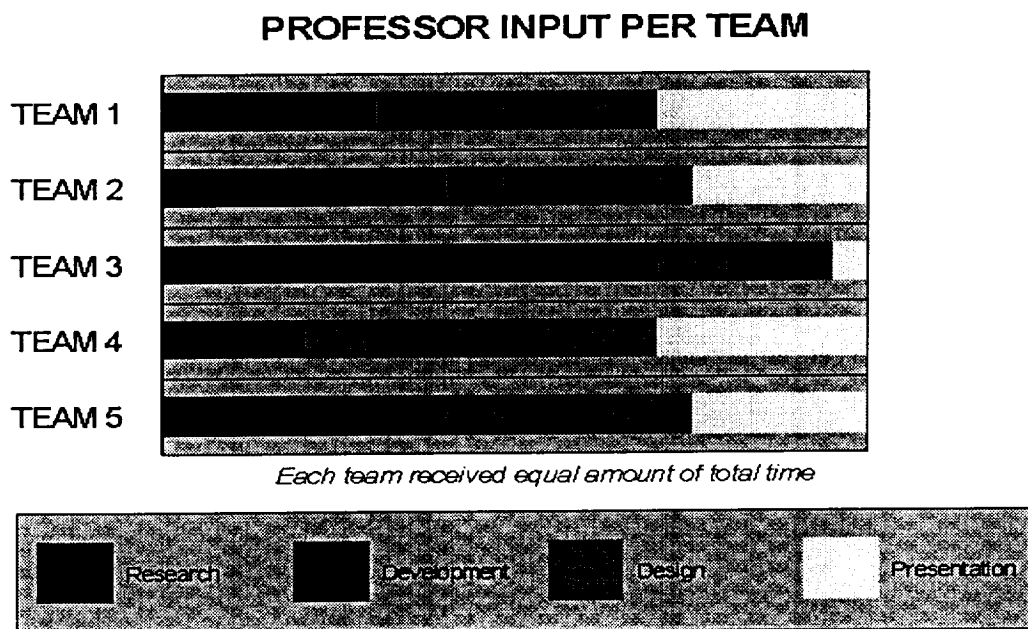
Each team was given 30 minutes to present their concepts and to field any comments. The students were interested in the NASA representatives input and selecting the concept direction to pursue for the final design. The comments during the team presentations proved helpful, but the best input was during informal talks after the presentation.

Final Design Development and Professor Input

Using the input from the NASA officials, the teams prepared criteria for their final design. Other study models, relocating glovebox components, and materials to build the final model became the emphasis for next three weeks.

As expected, several design questions surfaced. These were answered by the team, myself or they were referred to Terry Jones. At this time, I became interested in my degree of input in different areas with each team. I planned to use my input as a grading factor until I realized that the majority of questions were based the effects of zero gravity. However, I did use the presentation phase as a grading factor. For some teams, input in presenting their concept provided a clearer understanding of their design.

Each team, to my best ability received equal amounts of my time. It is interesting that most of my input was in the development and final design phase as the bar graph below indicates.



Team 4, required more design input because the concept can accommodate two users. Developing this concept was especially awkward because the users addressed the glovebox from the sides. Team 1, also received a lot of input in the design phase, primarily because they had a different understanding of the comments from the concept presentation.

Final Presentation at NASA

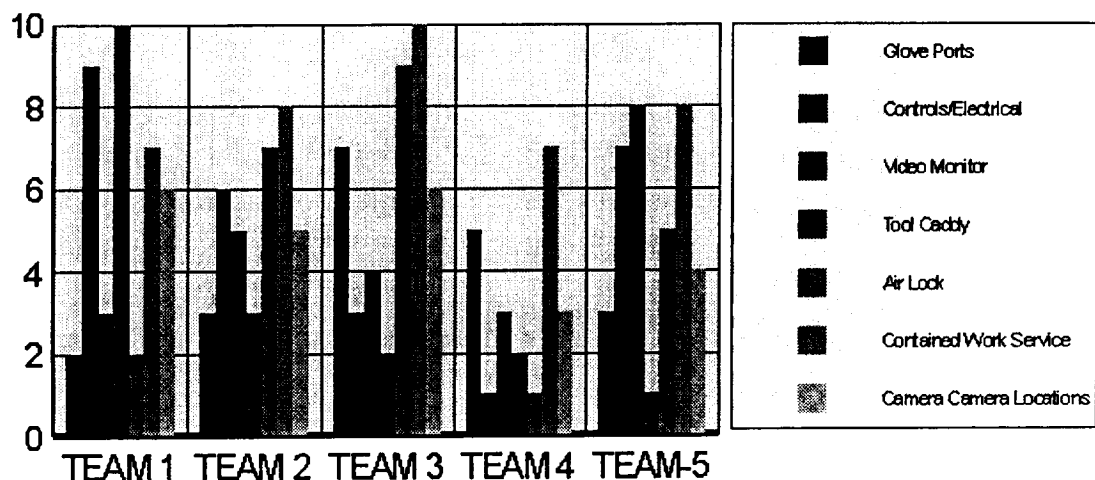
Preparing for the final presentation, the teams developed models that depicted the actual components of their glovebox, constructed the model to allow for shipping to the presentation site, completed their design report, and planned their oral presentation.

On May 27, 1994, the students presented their final design supported by a full-size model and a detailed slide presentation. The important feature of a design presentation is a precise, confident understanding of the problem followed by a strong design that solves the problem accurately. From the applause, the students must have met the results that Steve Hall, Terry Jones, and the NASA officials expected.

In their final, each team placed different emphasis on the components of the glovebox. In the bar graph below, the glovebox component emphasis of each team is compared. Most of the teams placed their emphasis on the contained work volume and the remaining components varied in design priority.

TEAM DESIGN EMPHASIS

Design Components of Glovebox



Degree of emphasis is shown in the higher value

Team 2, balanced the component emphasis better than the others, giving the airlock and the contained work volume more emphasis. Team 5, the second best balanced, required a fixed position for the user that placed the user directly in front of the video monitor. Glove ports, surprisingly, received about the same amount emphasis from each team. All of the teams provided adjustable glove ports to accommodate the different percentiles of users. Teams 2, 3, and 4 provided greater movement for the arms in their glovebox designs. Team 1, placed most of their emphasis on the users hands. This is evident in their idea for a drop-down-drawer tool caddy and their emphasis on mounting external cameras with magnets. Team 3, provided the best solution for accommodating the different percentiles of users. Their concept for the contained work volume pivoted to allow the user to be positioned comfortably.

The teams left their glovebox models and design reports with Terry Jones. The models and the reports will be used to develop a working prototype.